Design Evaluation and Technology Transition: Moving Ideas from the drawing board to the Fleet.

"Development issues in transitioning decision support technology to the Fleet."

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Overview

- What is decision support? How does it relate to decision aiding or advanced automation technology?
- Why should you care about decision support?
- How do we incorporate decision support into C4ISR systems? - Decision Centered Design

What is decision support?

- **Identifying all the data required to make a decision, gathering it together organized as meaningful information**
  - presenting it where it is needed,
  - when it is needed,
  - the way it is needed.
- **Note: Decision support is philosophically different from decision aiding and adaptive automation in that by design we do not take decision making away from decision makers by reallocating it to automation.**

What is decision support and why should you care?

- Fleet decision makers are faced with too much *data* - not enough *information*.
- ONR has conducted significant research effects of stress on tactical decision makers & how they can be mitigated through decision support & training interventions Reduced manning requirements, complex mission requirements, etc. further exacerbate the problem.
- SSG XVI "Command 21 - Speed of Command" recommended & CNO endorsed immediate application of **User / decision-maker centered design; Decision support technologies to command & combat echelons.**

Decision Centered Design

Command 21 - "Speed of Command"

"Enabling 'Knowledge-Centric Warfare' for Fleet Decisionmakers"

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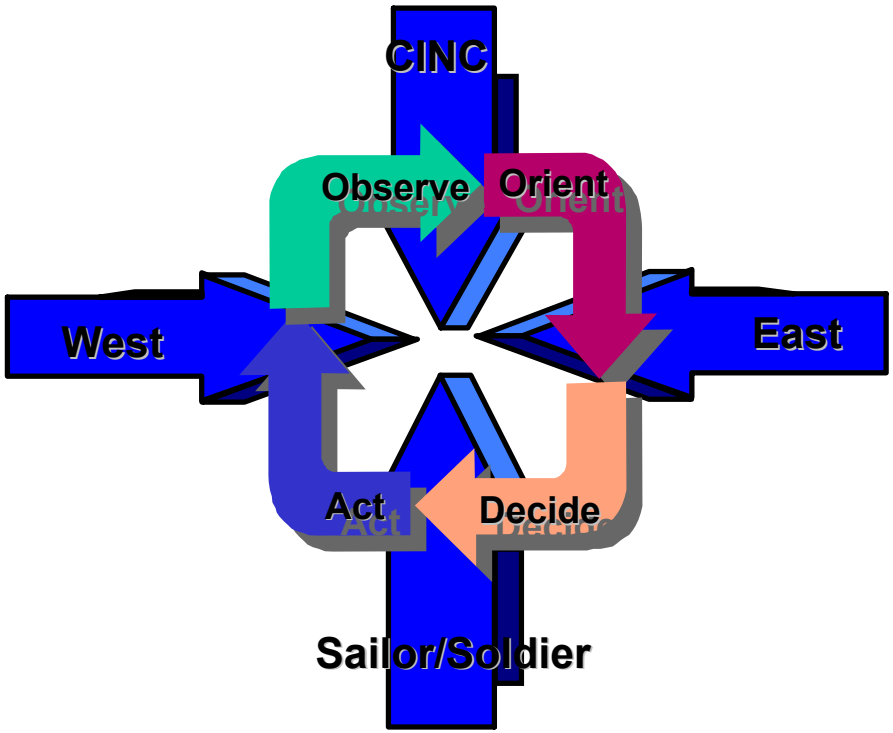
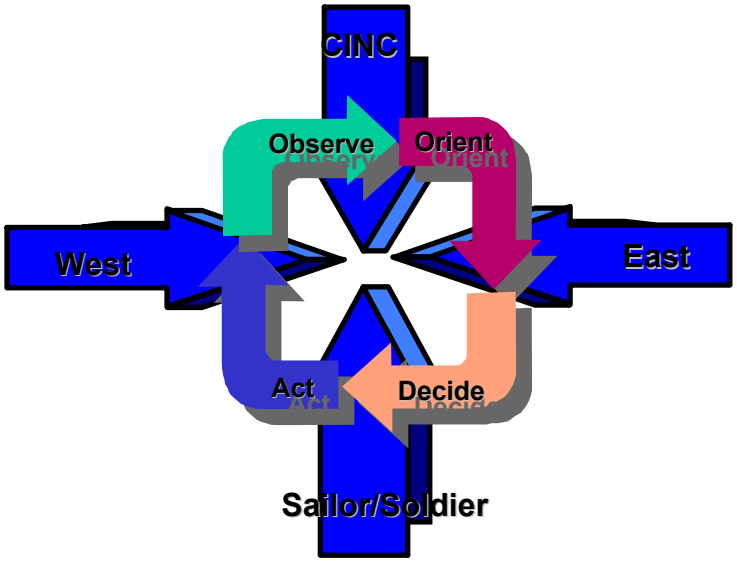
Knowledge Centric Warfare: Increasing the Speed of Command

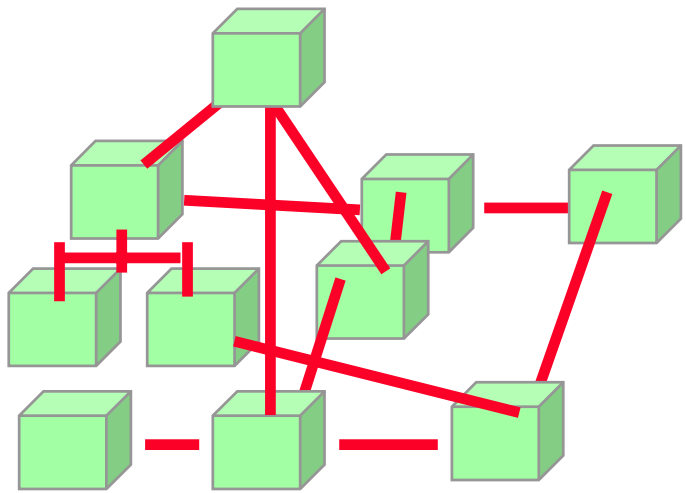
Move the knowledge, not the people



Rethinking Organizations in a Networked World

Move the knowledge, not the people

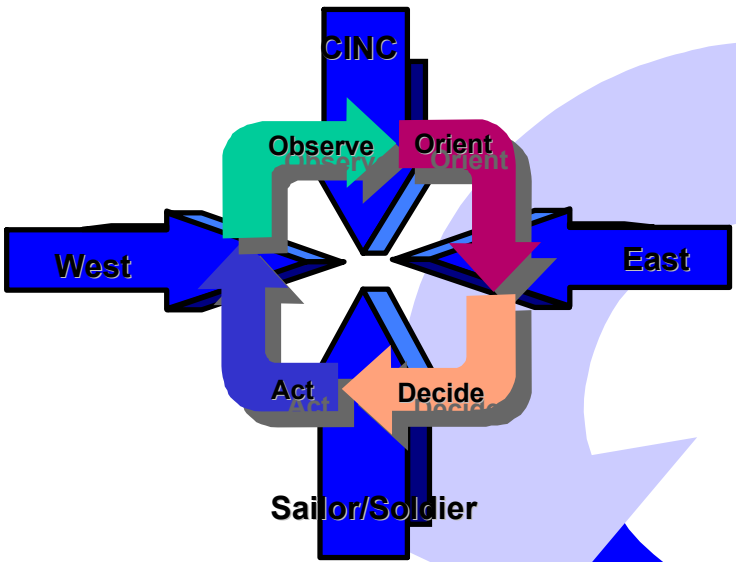


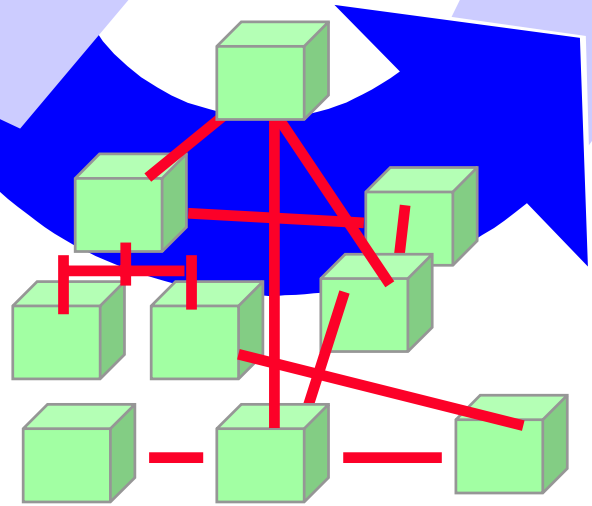


Networked Organizations (Adaptive, 3-D)

Knowledge-Centric Warfare

Move the knowledge, not the people



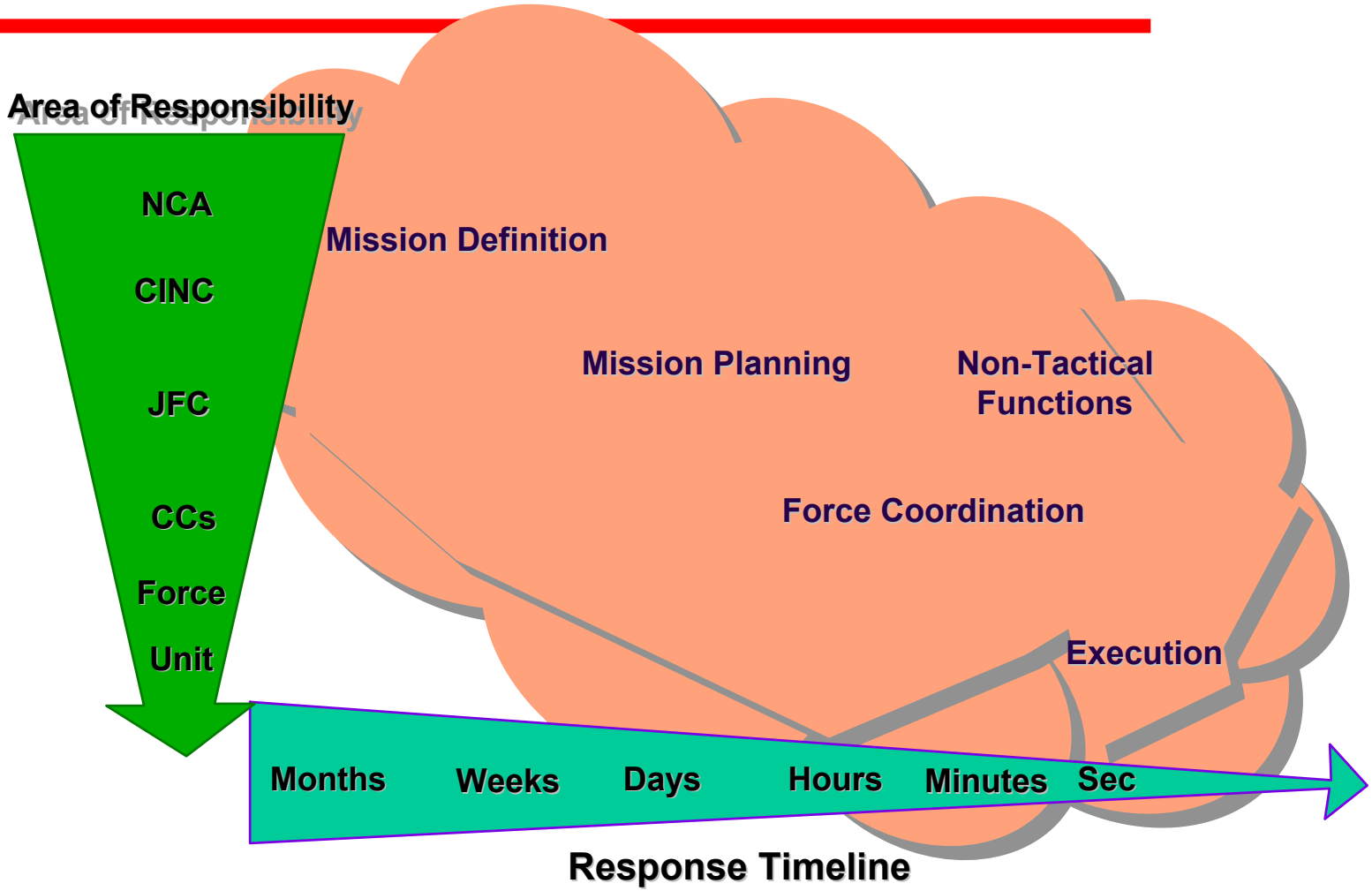


Networked Organizations (Adaptive, 3-D)

C4ISR Today


Area of Responsibility
NCA
CINC
JFC
CCs
Force
Unit
Mission Definition
Mission Planning
Non-Tactical Functions
Force Coordination
Execution
Months
Weeks
Days
Hours
Minutes
Sec
Response Timeline

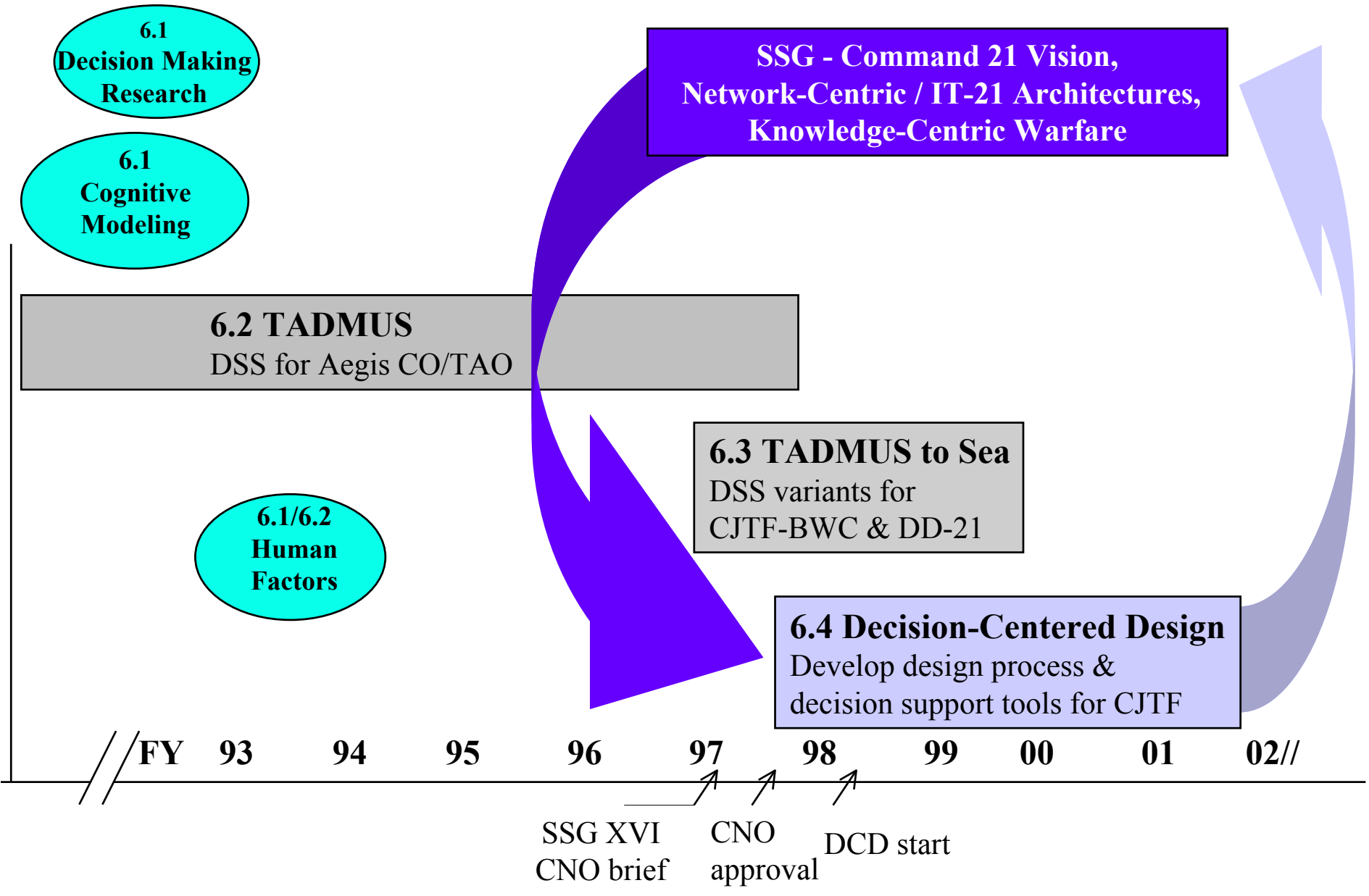
Tomorrow: Precision Execution Through Totally Integrated C4ISR



Decision Support: Implementation Issues

- **What is required to implement decision support technology?**
  - Understanding of the underlying need for decision support technology in a specific application.
  - Understanding of what other technologies & trends relate.
  - Vision of how the technologies fit together
    - N-tier C4I infrastructure
    - A systems engineering methodology that incorporates Cognitive Task Analyses / Knowledge Engineering.

Decision Centered Design Family Tree



The Command 21 Problem

- Fleet decision makers are faced with too much *data* - not enough *information*.
  - Fog of War and stress exacerbates the problem.
  - Reduced manning requirements, complex mission requirements, etc. further exacerbate the problem.
- TADMUS, et al. demonstrated that effects of stress can be dramatically mitigated through:
  - User / decision-maker centered design
  - Decision support technologies
- Fleet information systems are often not designed to support the decision makers.

DCD Project Objectives

- **To meet the Navy's Needs, the DCD project must:**
  - **Develop a formal design process that addresses the needs of the user.**
  - **Evaluate the design process in terms of operational impact across a variety of Navy applications and command echelons.**
    - **Training**
    - **Manning**
    - **Doctrine**
  - **Establish entry & exit criteria for program managers.**
  - **Adapt TADMUS tools and methodologies for other users, e.g. CJTF, HQ-21, Ring of Fire, JCC(X), etc.**
  - **Research, identify, integrate and leverage other enabling decision support technologies.**
  - **Integrate decision support technologies with current & planned, Navy C4I & combat system, infrastructure .**

DCD is a New Focus for Systems Engineering

Cognitive Task Analysis & NDM

Presentation Technology

Knowledge & Expertise

Performance Barriers

Information Requirements

Information & Decision Theory

Training & Doctrine

Stressors:

Time Pressure

High Stakes

Uncertainty

Must do something

Decision Requirements

Decision Centered *system design*

+

Decision Centered *training*

+

Decision Centered *organization*

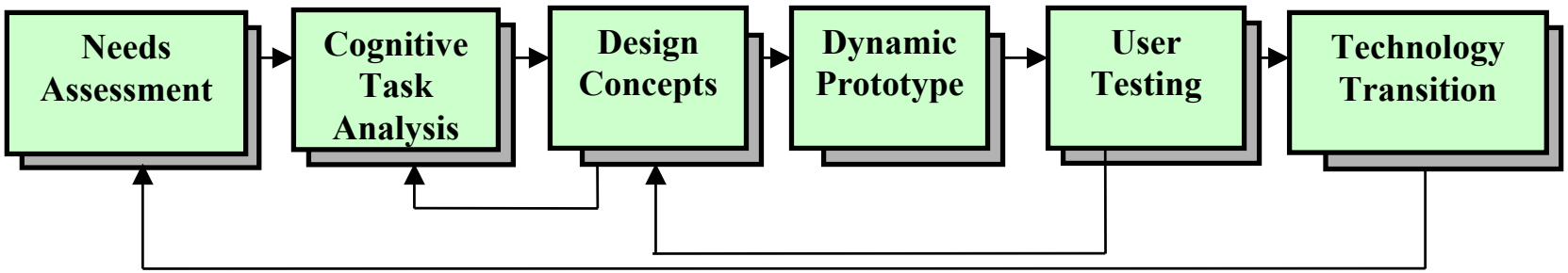
=

Improved Decision Making & Reduced Manning

Naturalistic Decision Making

- **Experts make decisions differently from novices.**
  - Experts use heuristics as decision making shortcuts.
    - Recognition-Primed Decision Making
    - Explanation-Based Reasoning
  - Heuristics lead to *biases* & can cause *error*.
    - Framing
    - Anchoring
    - Confirmation
- **Stress Affects Performance.**
  - Hypervigilance (Impulsive action)
  - Intolerance of ambiguity
  - Fixation on primary task / Tunnel vision
  - Less communicative
  - Short-term memory degradation

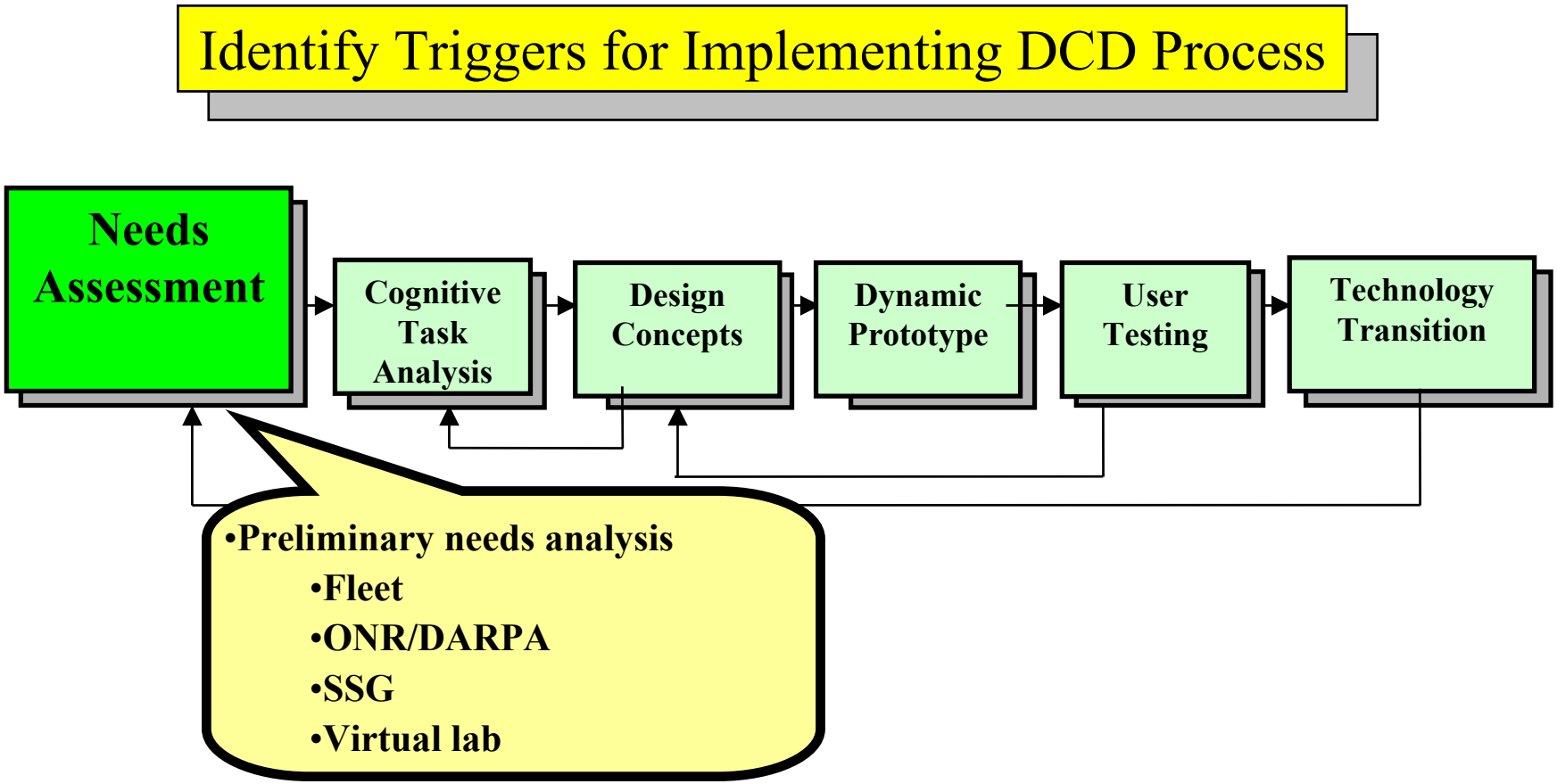
DCD Functional Process



DCD is necessarily:

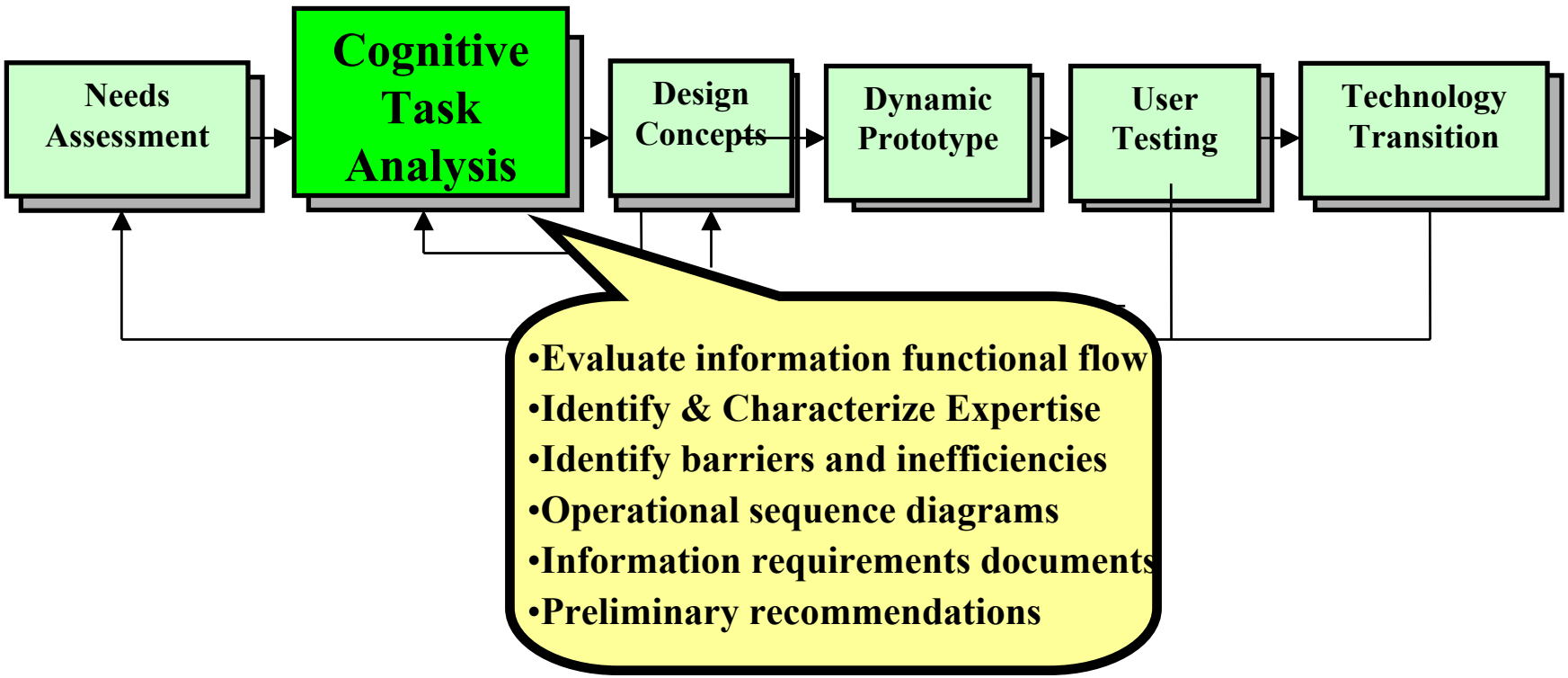
- Based on user & SME inputs,
- Reliant on rapid prototyping,
- Employs empirical, scenario-based testing,
- An iterative process.

Needs Assessment

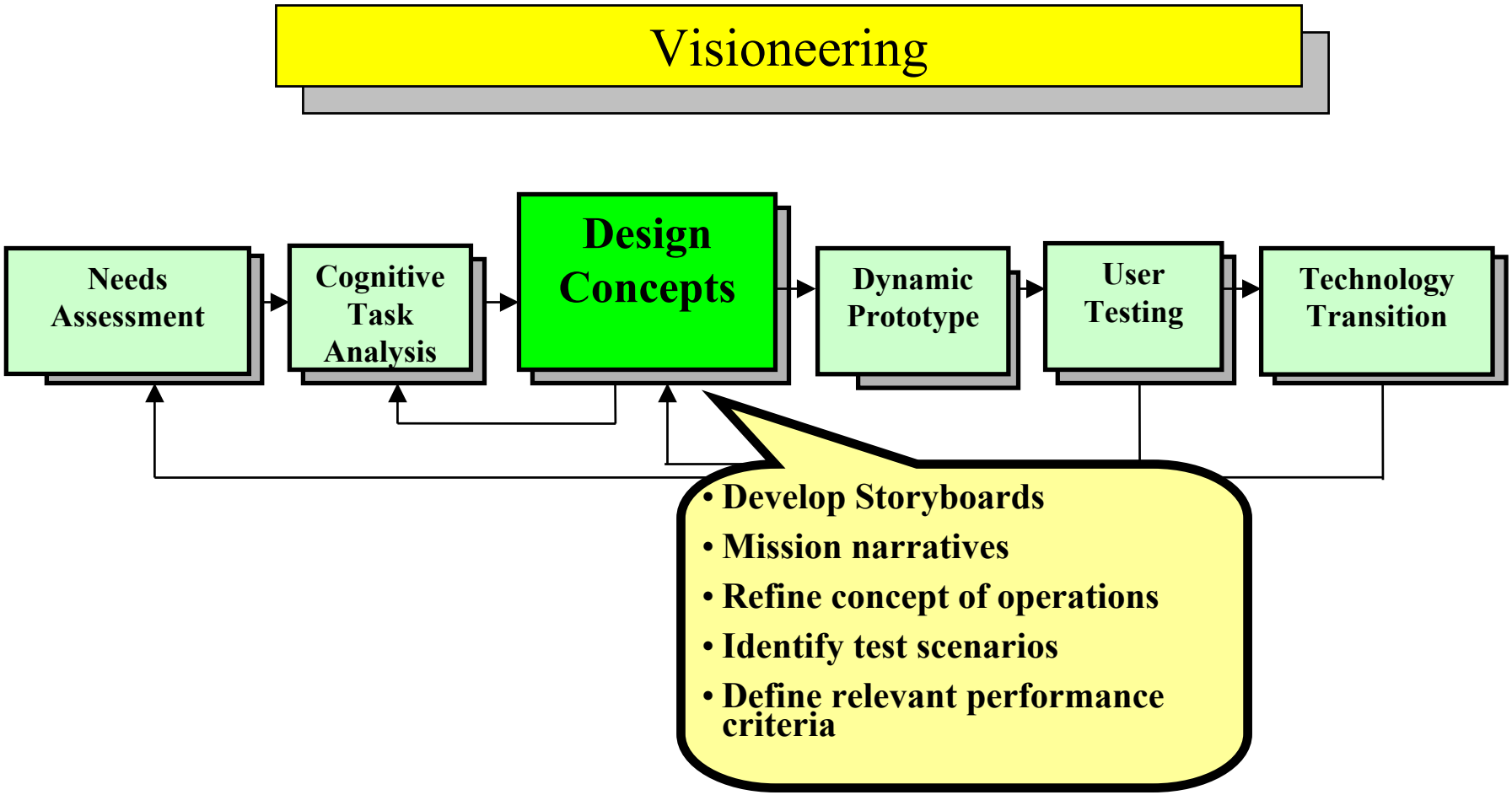


Cognitive Task Analysis

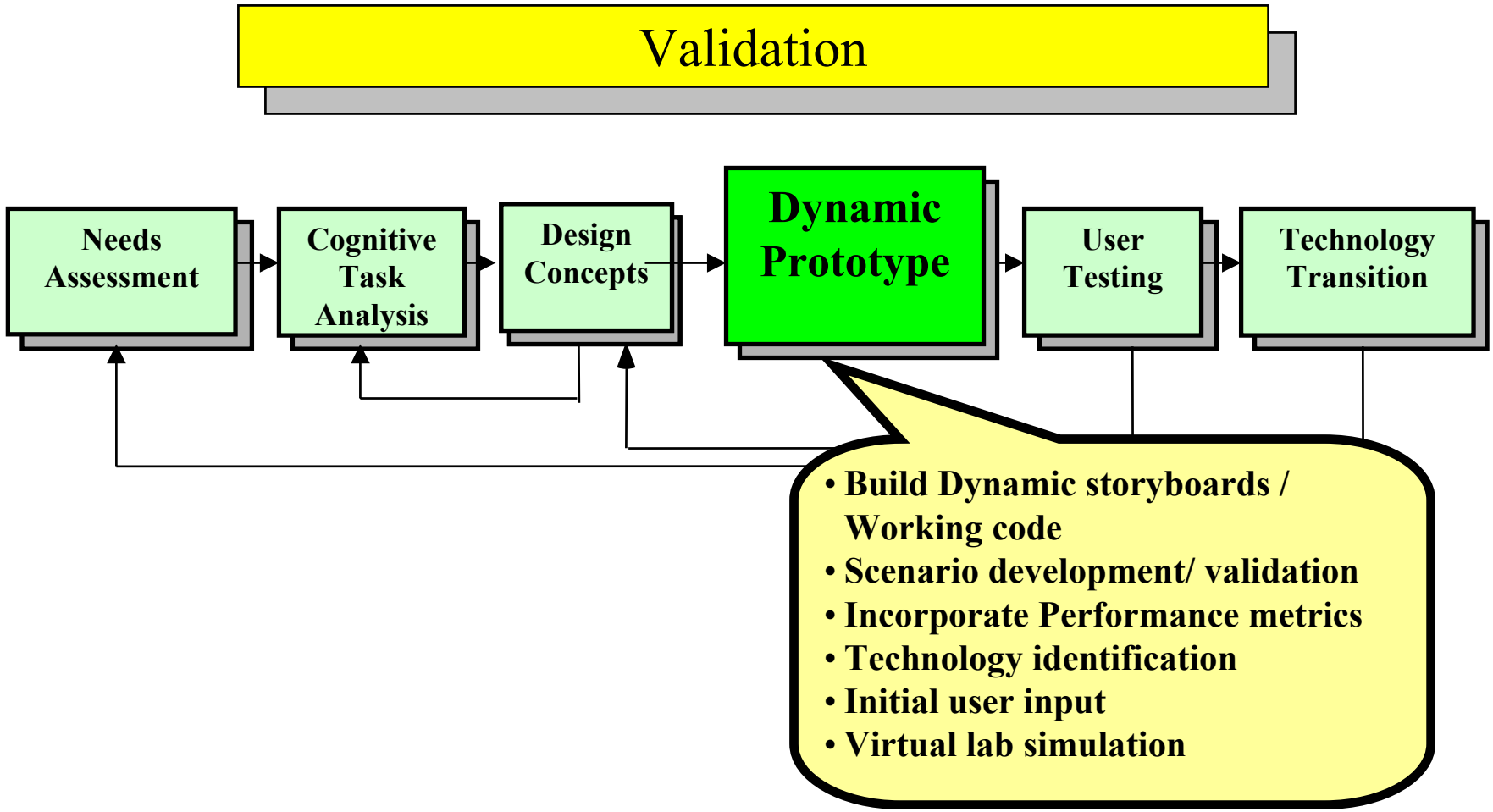
Develop a Formal representation of the decision makers' tasks



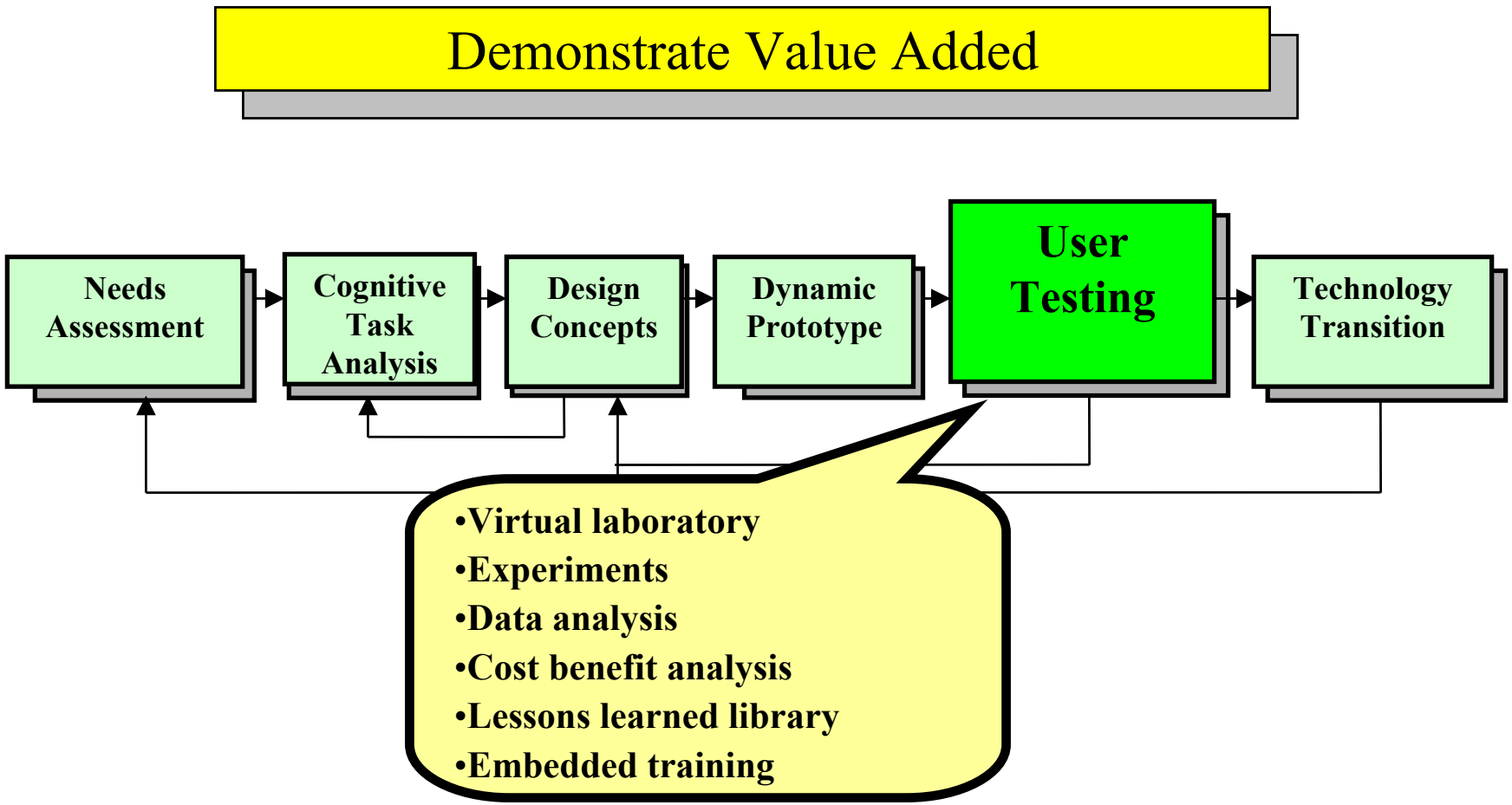
Design Concepts



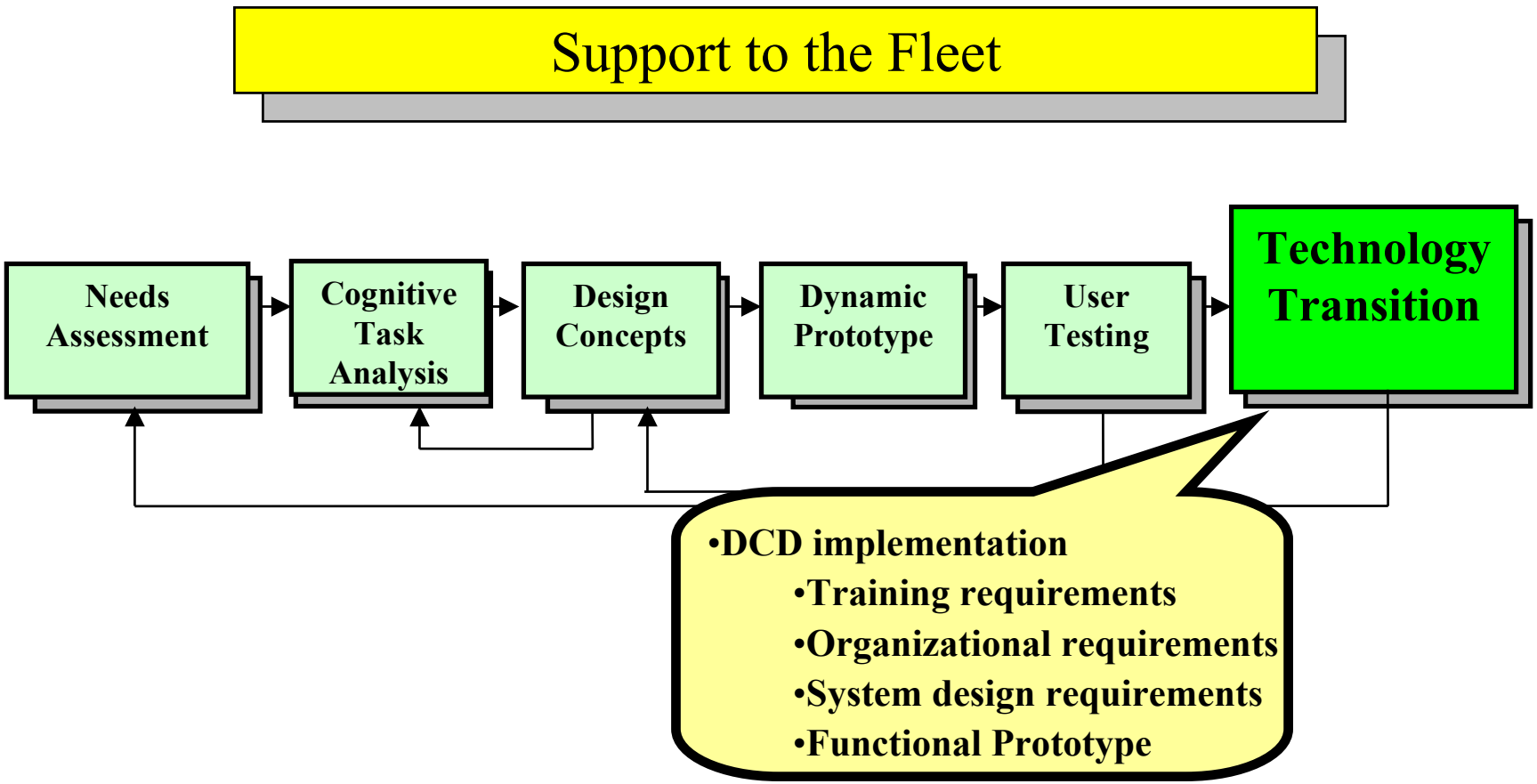
Dynamic Prototype



User Testing



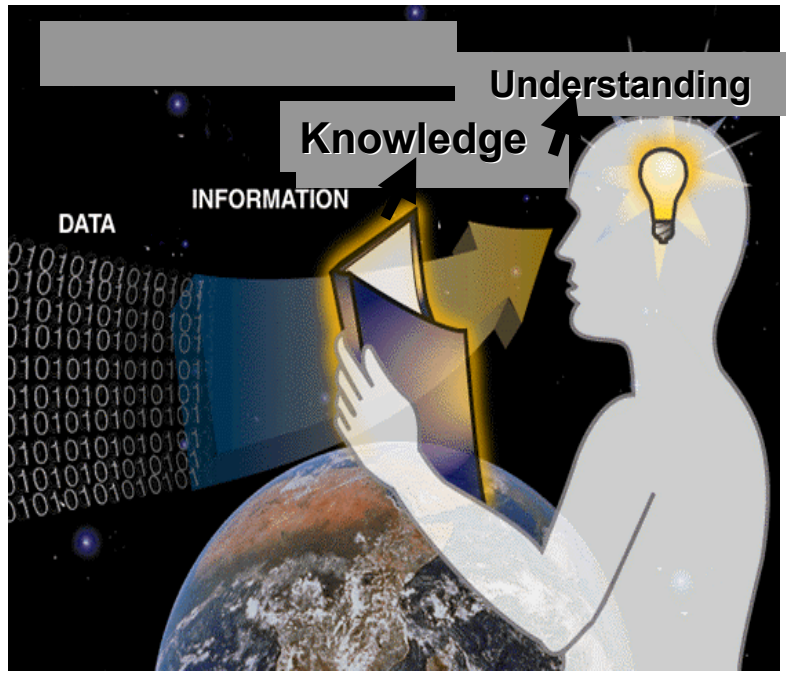
Technology Transition



Centers of Gravity for Information Technology

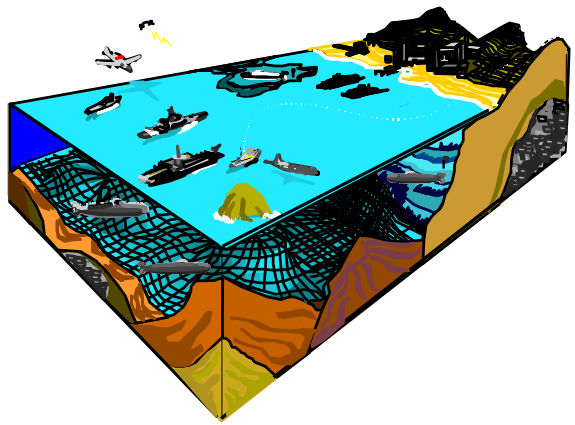
The Next Generation Levers:

- **Collection and fusion**
- **Webs and nets**
- **Automated reasoning**
- **Collaboration**
- **Human-computer interaction**
- **Cognitive support**



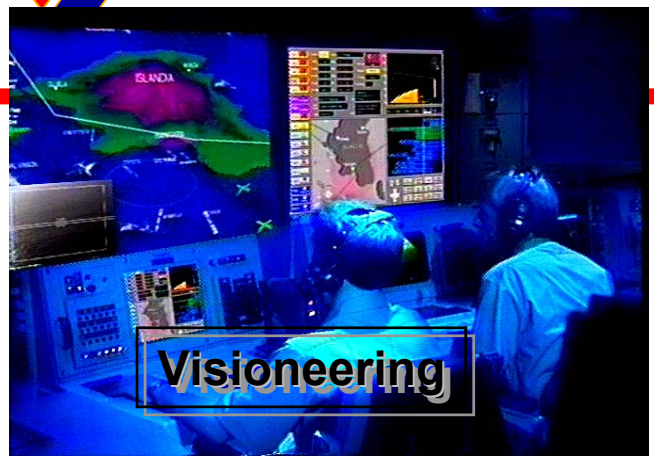
Transforming Information Into Knowledge

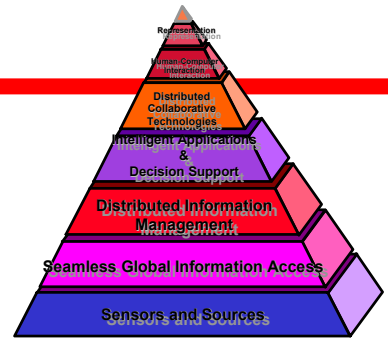
- Systems with higher order reasoning capabilities
  - Access to, and Aggregation of data
    - Interaction between Information
      - Introspection & Evidential Reasoning on Information
- Synergy between computational and cognitive reasoning
- Visualization of complex knowledge



Next Generation C4ISR Through Focused Investment

SPAWAR





Notional Architecture

DoD Technology Investment

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$

Industry Technology Investment

COTS
COTS
COTS
GOTS
GOTS
GOTS
COTS

The Roadmap

Commercial OTS
Advanced Technology
CCOF (IRUS)
Legacy Systems
DII Common Op Environment

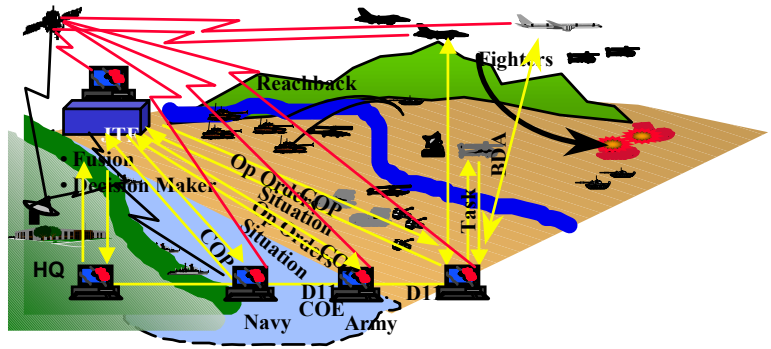
Systems Engineering and Integration

AWE
ACTD
JWID
....

Transition

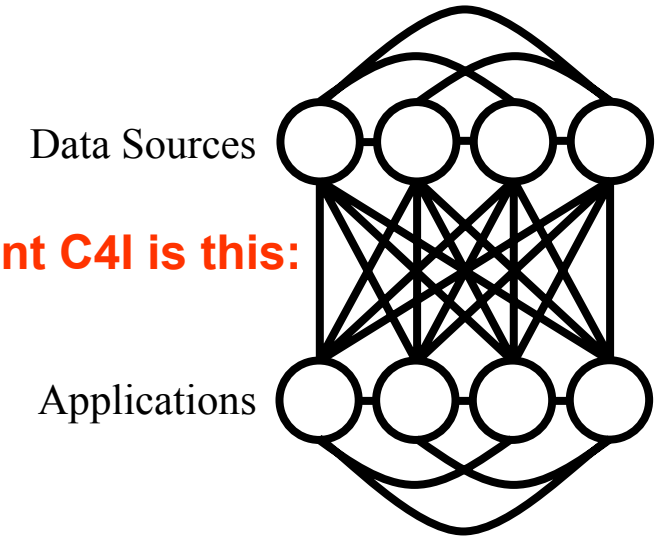
Current State of C4ISR:
Serious challenges to implementing Decision Support

- **Multiple data architectures**
- **Multiple Data Types**
  - **Real Time Tactical**
  - **Intelligence Databases**
  - **Imagery**
  - **Multimedia**
  - **Non-tactical (MS Office products)**



- **Conflicting data from redundant sources**
- **Tower of Babel process architecture cannot integrate/deconflict data from multiple data architectures**
- **User application specific data access (users cannot drill into other applications' data)**
- **Limited scalability of data server synchronization**
- **Minimal information awareness, access, and delivery within and across communities**
- **Commanders have limited and inflexible information resource control**

Current C4I is an impediment to implementing Decision Support Technology



Current C4I is this:

Stovepipes !

- **Numerous Independent Data systems**
- **Data and applications intertwined**
- **Data from one system not available to others**
- **Poorly integrated - bridges ad-hoc and often incompatible**
- **Complex, high skill levels required, and *lifecycle cost* prohibitive (development and maintenance)**

Decision Support Requirements from C4ISR

- **Easy access to all kinds of data**
- **Compatible with both legacy and long term C4I infrastructure**
- **Allows Intuitive displays based on CTA & Cognitive theory**
  - Multi-dimensional browsing *(geographic, spatial, temporal, relational, etc.)*
- **Data drill down capabilities**
- **Automate simple processes for user *(conversion, formatting, display, updating)***
- **Provide automation for user definable tasking *(state id, task completion, alerting, etc.)***

LEIF - Lightweight Extensible Information Framework

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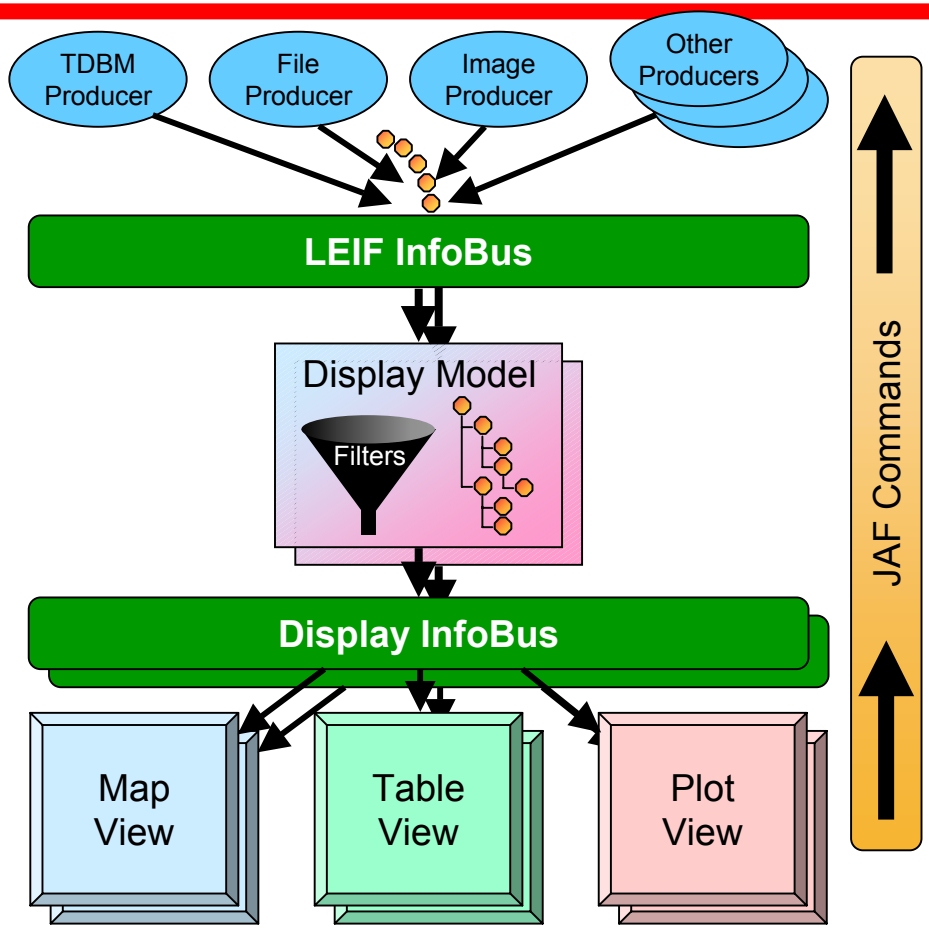
Design Criteria

- **Implement a flexible client architecture that allows the addition of new data sources and client capabilities at minimal cost/effort**
- **Implement client architecture that can be as thin as possible**
  - Demand loading of classes/functionality
- **Utilize existing data sources**
  - TDBM, ITS, MIDB, ASAS, etc.

Philosophy / Approach

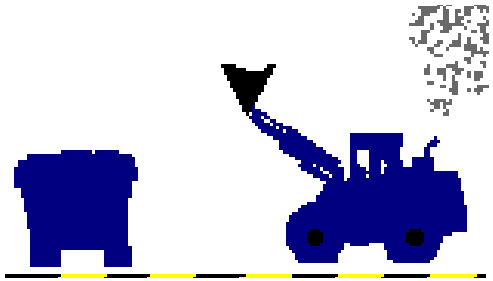
- **Data should be treated as display-independent objects (Model/View/Controller)**
  - Model contains the core functionality and data
  - View displays information to the user
  - Controllers handle user input
- **Browsers/Viewers are used to display & interact with data along specific dimensions**
  - Use data-view tools for specific product display
- **Build as a development environment**
  - 3rd party addition of new data sources and viewers
- **Use emerging industry standards wherever possible**

LEIF Architecture Overview



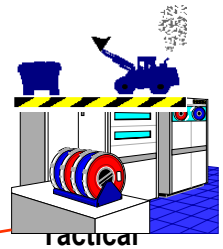
- **LEIF is a Framework**
  - Independently developed Extensions are "plugged in"
  - Producers interface to any data source
  - Consumers process produced data
- **Views display processed data in multiple configurations**
- **Display Model - a Consumer; organizes and filters data for Views**

How a LEIF Producer works

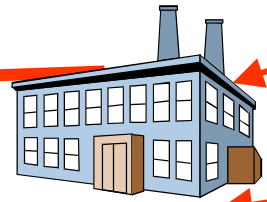


1. Gathers data from the remote source

Fused Information Repositories



Tactical Intelligence Repositories

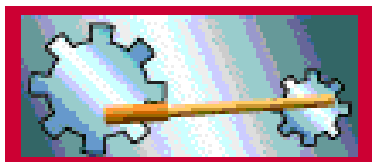


National Intelligence Repositories

Operational Repositories

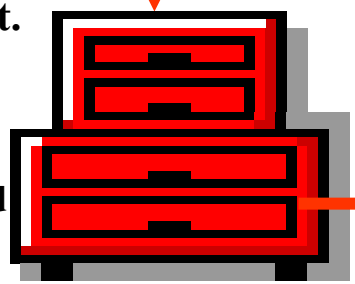
Policies
C2
METOC
CASREP
MEDICAL
TBD

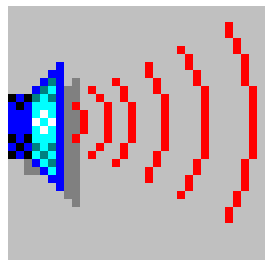
2. Applies Domain Policy Translators to



translate the data into a common " object " representation

3. Builds an Object.
Puts the data in - *perhaps* display properties & some Owner recommended Tools to process it.

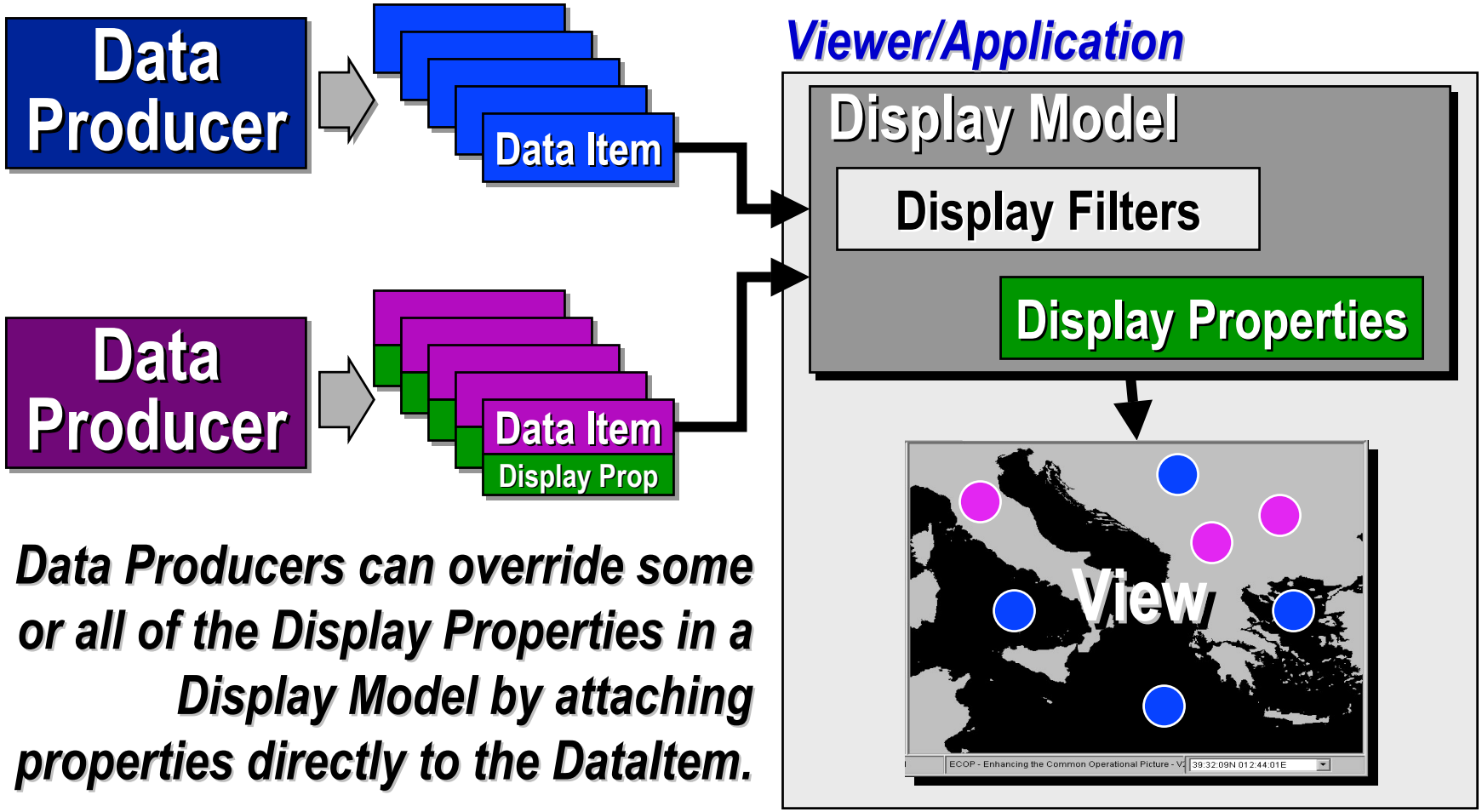




4. Announces on the Info Bus, an Object was created

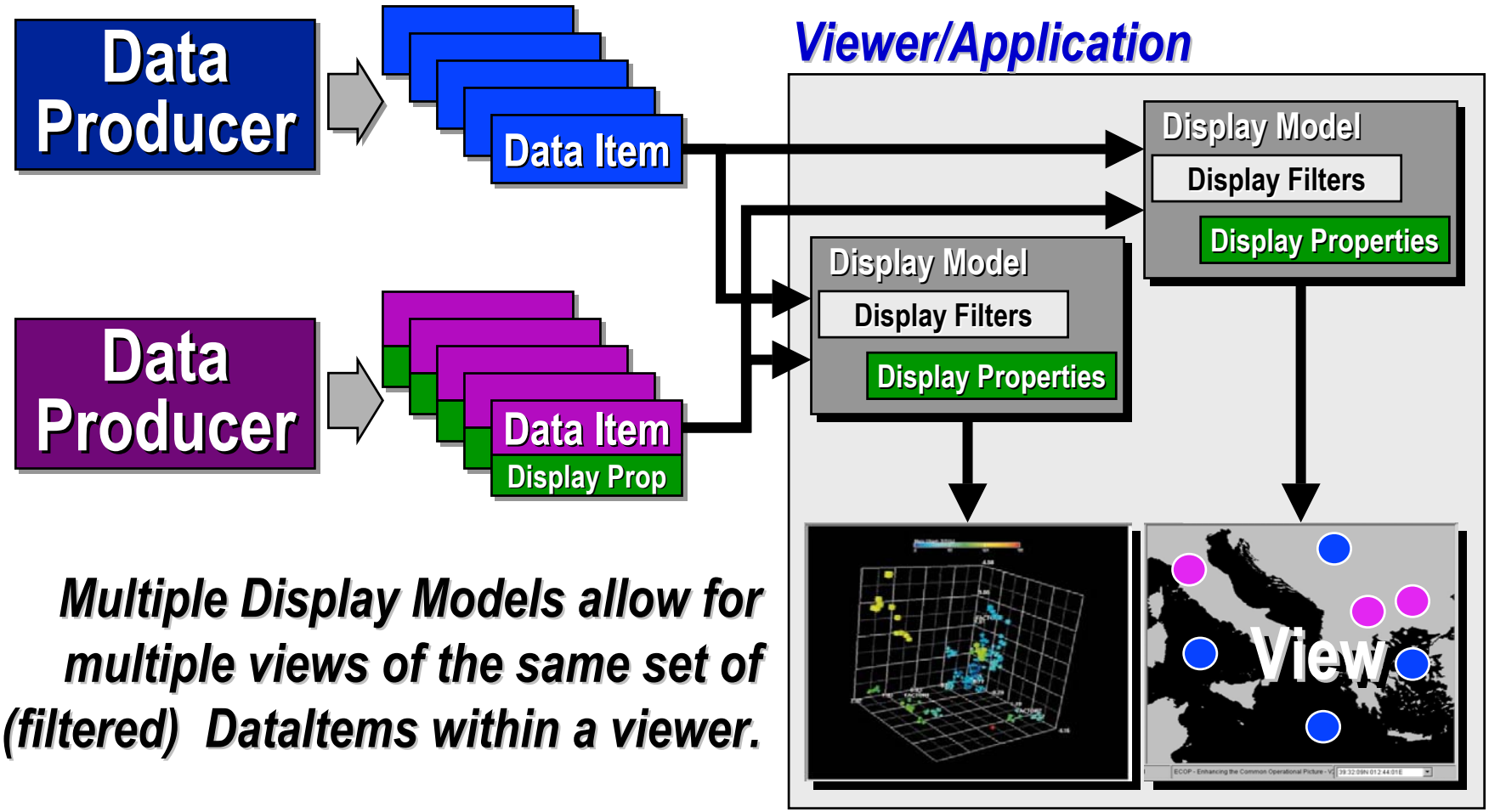
(LEIF does not mandate any particular storage Model e.g., File based, Object or Relational databases or distributed computing architecture e.g., RMI, CORBA, or COM as a result of how the Producer works.)

Display Models & Filters



Data Producers can override some or all of the Display Properties in a Display Model by attaching properties directly to the DataItem.

Multiple Display Models



Multiple Display Models allow for multiple views of the same set of (filtered) DataItems within a viewer.

How the LEIF Display Manager works

1. Data Producer: Provides Display Properties for the data type: **Tank**

Image +

Color: Sand
Speed: Km/hr
Weight: Kgs.
Fuel: Liters

Color: Green
Speed: mph
Weight: lbs.
Fuel: Gals

Color: White
Speed: mph
Weight: lbs.
Fuel: Gals

Data Producers can Override some or all of the Display Properties in a Display Model

2. Display Model: Manages data item Selection

3. Display Model: May have user-specified Display Characteristics for the data type **Tank:**

Color:	Yellow & blue
Speed:	Km/day
Weight:	Stones
Fuel:	Bales

4. Display Model: Filters the display properties, recognizes "data type Tank" and adds Display Characteristics

Color: Fuel: Speed: Weight:

5. Display Model: Announces the data item is available, to be displayed this way.

Color: Green
Speed: Km/hr
Weight: lbs.
Fuel: Gals

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LEIF built using COTS / MOTS Technologies

- JavaBeans
  - InfoBus
  - JavaBeans Activation Framework
  - BeanContext
- JFC/Swing
- JDBC, JNDI, JMF, JavaHelp, JNI, Servlet, JSDT (being examined)
- ECMAScript (JavaScript Standard)
- CORBA, COM
- XML

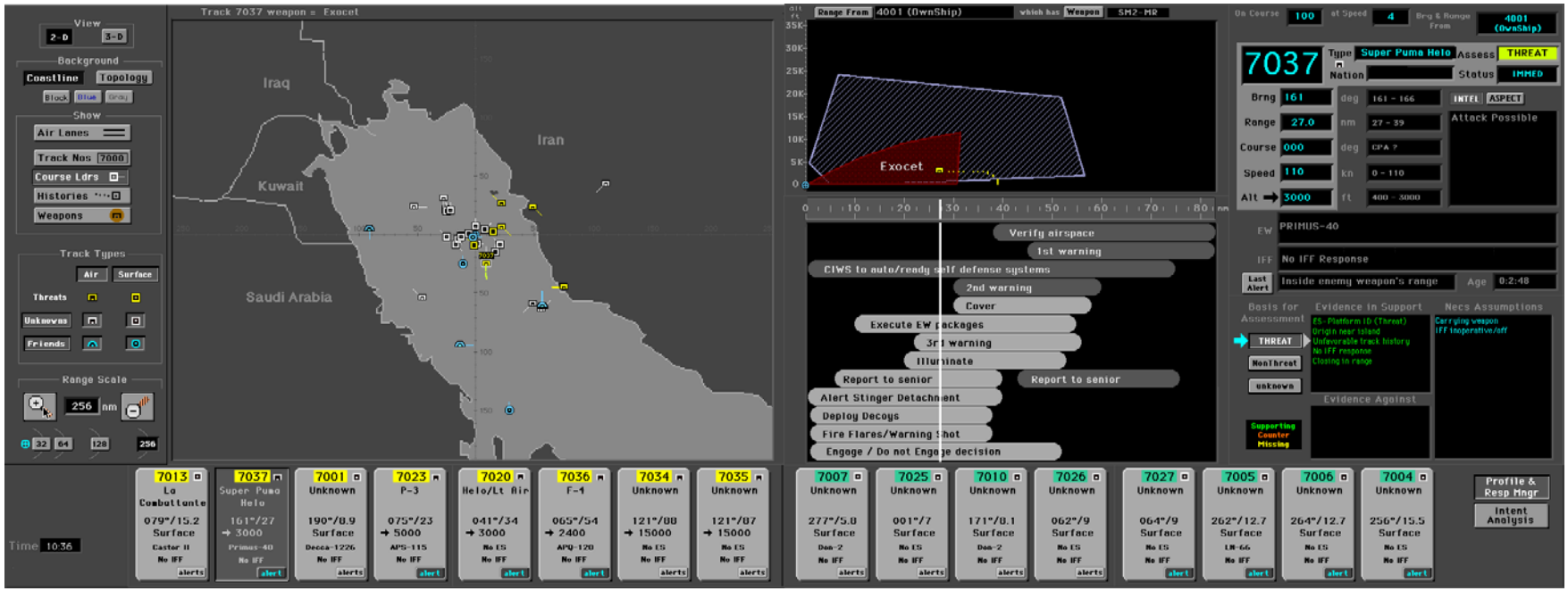
Active Desktop

- **Capabilities**
  - Drag & drop objects from any application onto any other application/container
  - Changes to an object in an application are reflected in all other applications using the same object
  - Automatic type/format conversion for app ingest
- **All DataItems are present in all Display Models, therefore simple manipulation of Display Model handles LEIF apps**
- **Use ActiveX bridge to drop into Microsoft Office products**
  - Conversion agents to format DataItems

LEIF Developer Summary

- **A developer who wants to create a Producer needs to know:**
  - How to represent their DataItems (allowable attributes and types)
  - How to register and submit DataItems to the InfoBus
  - How to add JAF commands
- **A developer who wants to create a View should know:**
  - How to use the display model
  - How to respond to events that the model has changed (TBD)
  - How to invoke JAF commands on displayed DataItems
  - LEIFv3 will provide APIs to add toolbars and menus to common top-level window

TADMUS DSS-2: CIC Conceptual Design



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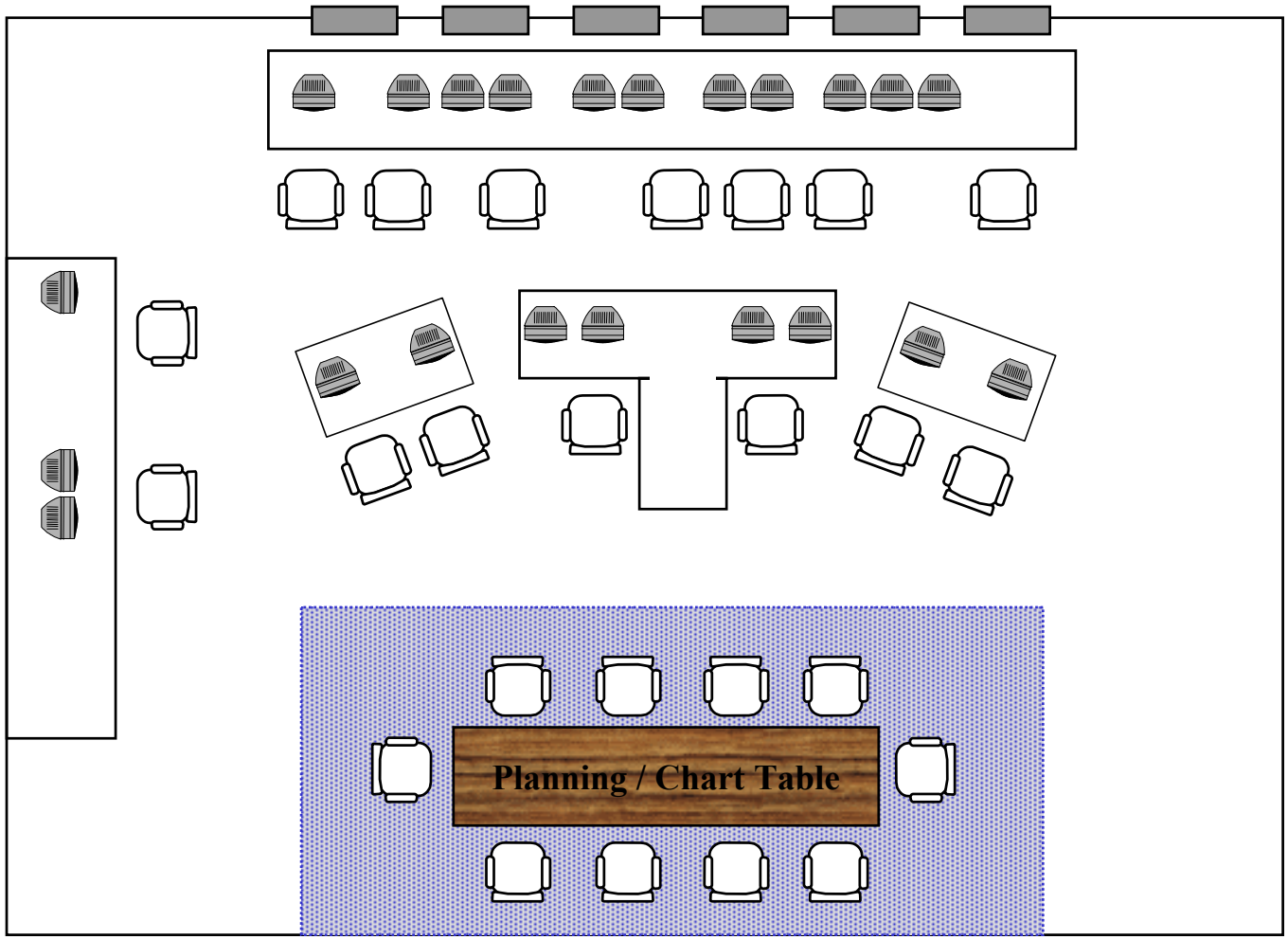
USS Mt. Whitney JOC - After Recent Re-Design



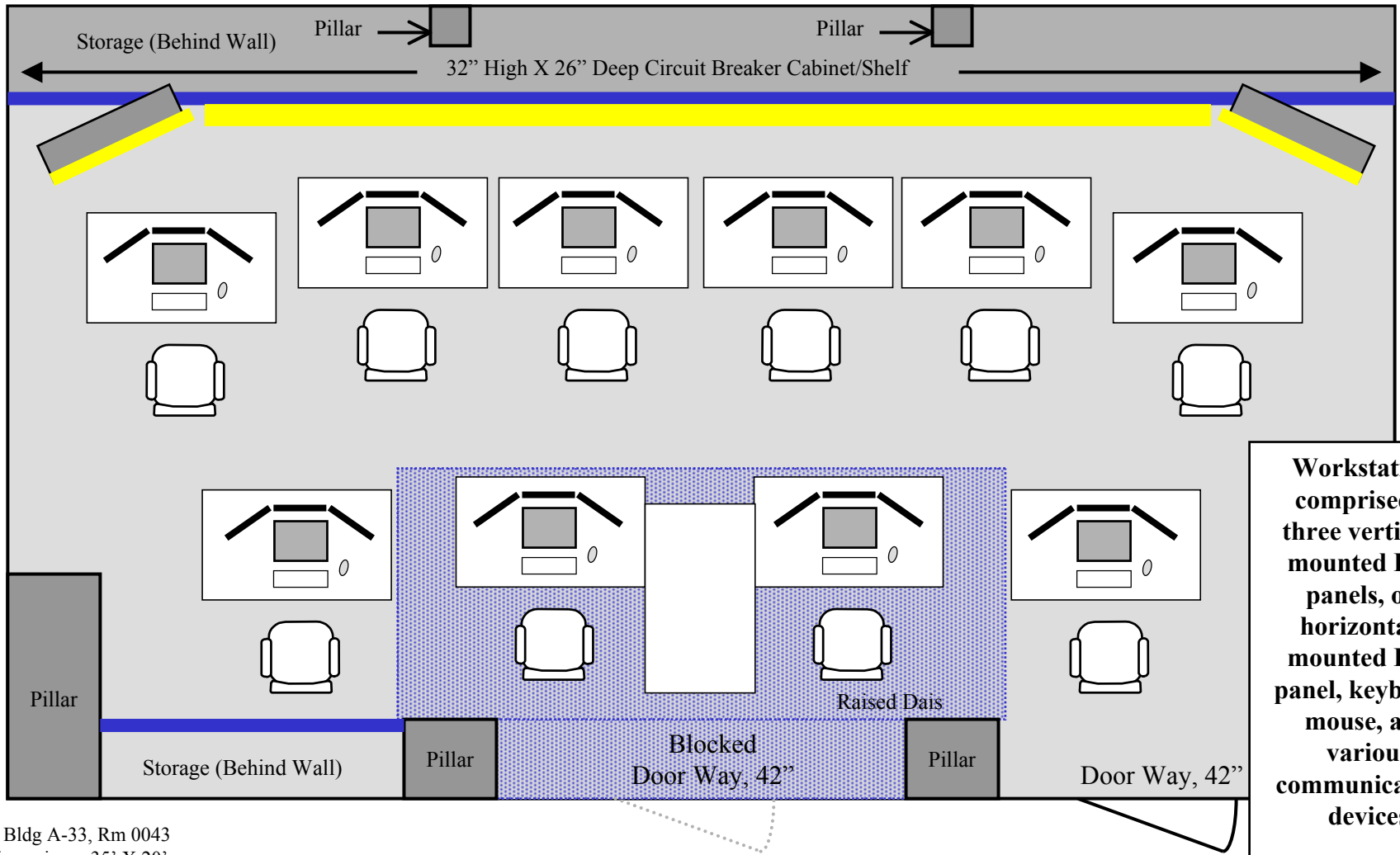
Lessons Learned - CJTF

- **BWC needs assistance integrating data and defining and displaying information to the CJTF and the battle watch when dealing with operational issues**
  - Intuitive “Summary” graphics
- **Anchor Desks need tools to facilitate providing “value added” information to the BWC**
  - collaboration tools, graphical representations of relevant data
- **Anchor Desks need ability to effectively monitor tactical / operational displays**
- **JOC requires an effective communications capability between watchstations**

Lessons Learned - CJTF (contd)...

- **BWC/Anchor desks need embedded training capability to accelerate learning curve for "augmentee" personnel**
- **Legacy displays are not optimal in supporting exchange of relevant information and aggregating data to represent meaningful information**
- **Collaboration across anchor desks is complicated by a myriad of applications and C4I metaphors being used (Windows/X-Windows/Internet browsers/GCCS-M, etc.)**

The CJTF Conceptual redesign… Proposed Layout

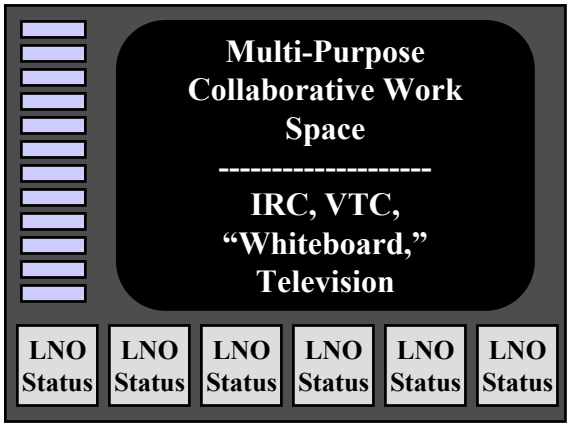


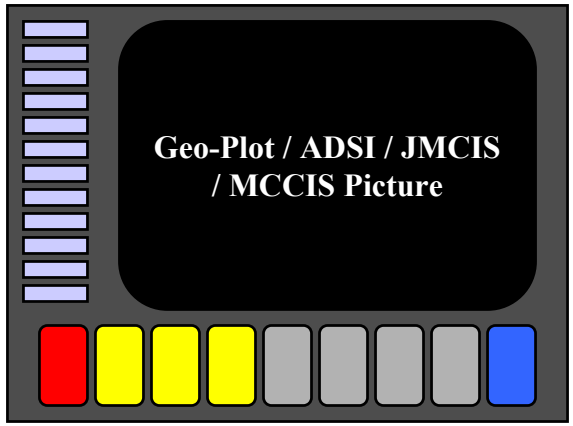
Workstations comprised of three vertically mounted LCD panels, one horizontally mounted LCD panel, keyboard, mouse, and various communications devices

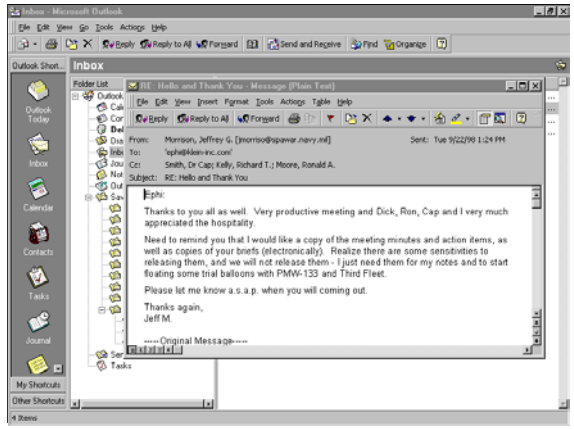
SSC-SD Bldg A-33, Rm 0043
Gross Dimension = 35’ X 20’
(Scale: 1” = 4’)

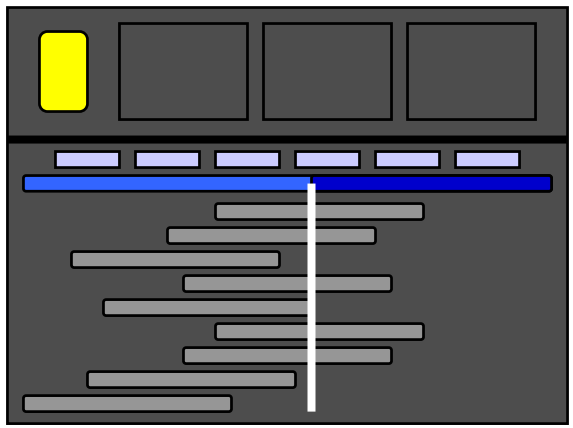
CJTF DSS Conceptual Design

Common design features across numerous function- and task-customized workstations (e.g., BWC, Anchor Desks, CJTF, etc.)









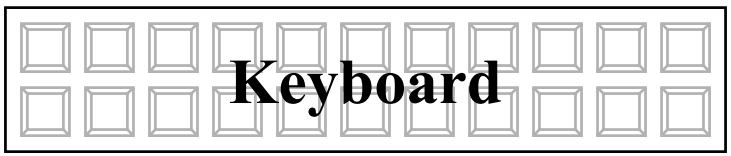
Communications Access Panel (Secure and Un-Secure Radio R/T Circuits)

Left-most and right-most displays angled 20° - 30° toward user

STU-III Phone

POTS Phone

(Lower display inset horizontally into work surface)



Mouse Area

Conceptual CJTF Collaborative Decision Support System:

A "Picture Window" into a "sea of information" displayed using a 4096x2304"data wall" & fed from Anchor Desk DSS's.

CJTF Anchor / LNO Desks Summary Displays across top.

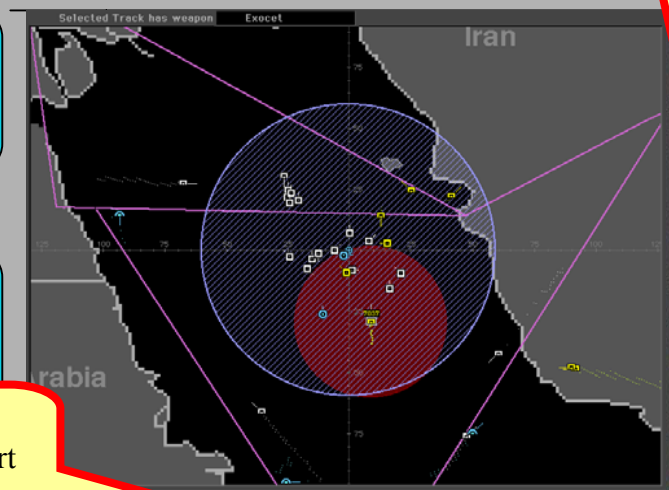
BWC would swap perimeter displays in and out of large collaborative displays through voice and/or gesture commands

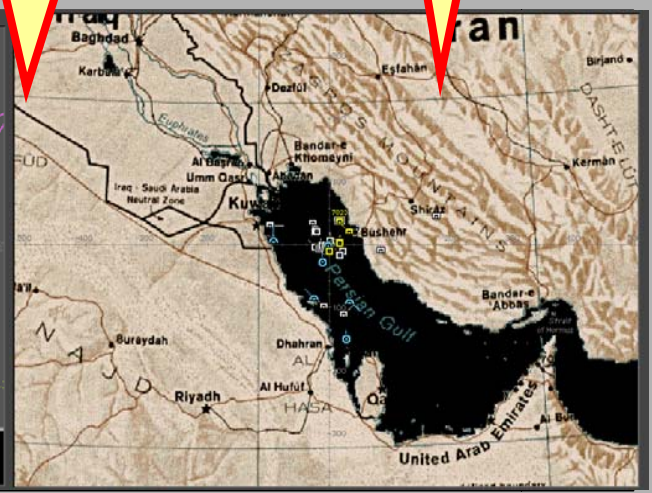
Large workspaces for *collaborative* decision making - amplify on summary displays in perimeter

INTEL | CIMIC | C4I Status | AIR/JFAC | USW | LOGISTICS | GROUND | METOC

VTC

VTC





VTC

VTC

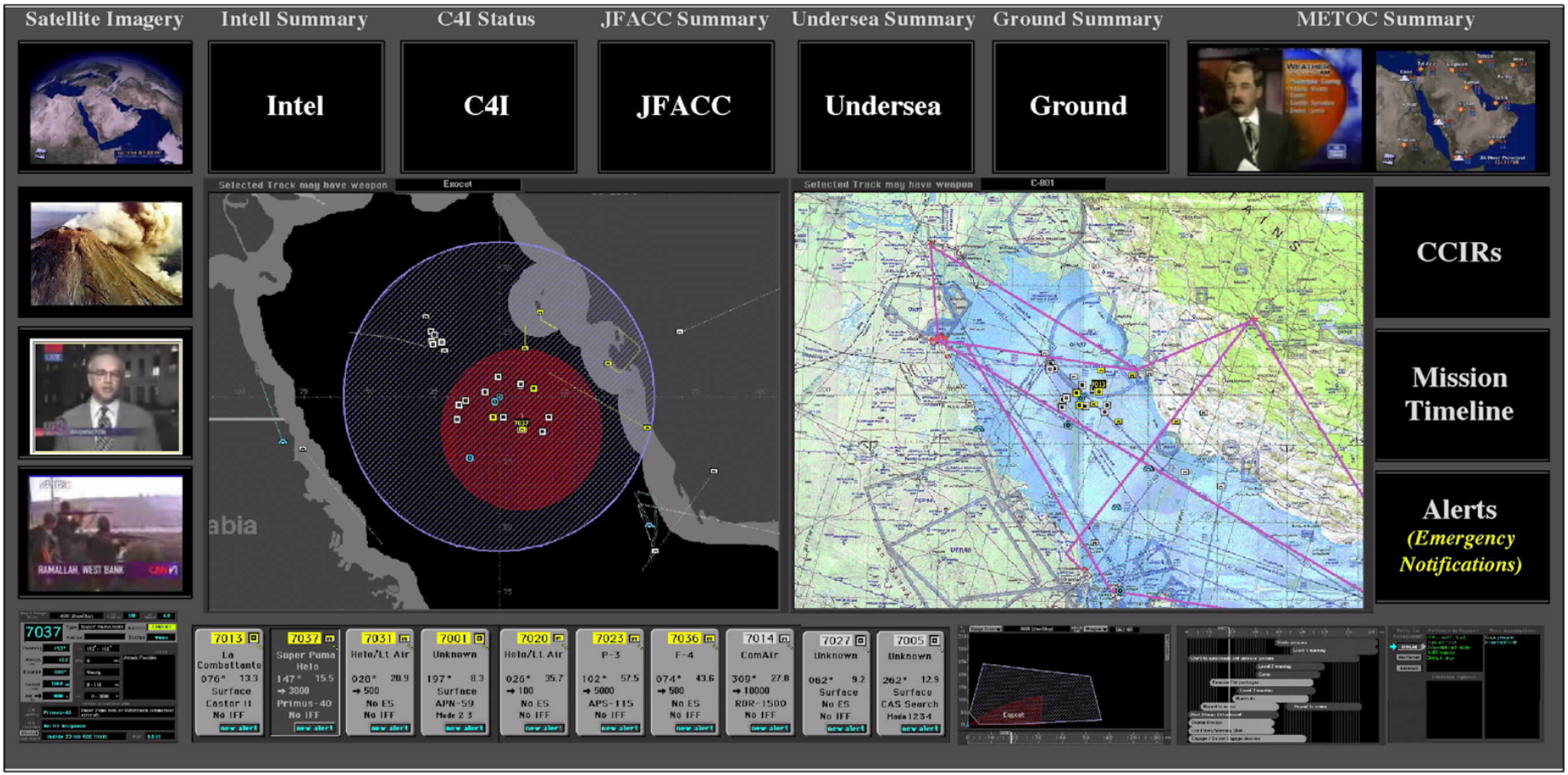
VTC

CJTF Decision Support Tools at bottom

ROE / Intnl. Law | Order Status OPORD/Execute/ Frag/Warning | Campaign Temp Mgr. | Operational Issues Mgr. | Contingency Plan Mgr. | Command Architecture/ Connectivity | PAO Events | Watch Turnover Brief

Conceptual CJTF Collaborative Decision Support System:

A "Picture Window" into a "sea of information" displayed using a "data wall" & fed from Anchor Desk DSS's.



Decision Centered Design

Information Systems for Fleet decision makers that:

Are applicable to ALL command echelons & mission areas,

Enable Knowledge Centric Warfare with IT-21 infrastructure (and beyond),

Essential to effective use of limited manpower,

Key to achieving "Speed of Command".

"Very soon, this will become most important"

- VADM Cebrowski